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A Vision "Bolt-On" Item Could Increase the Discriminatory Power of the EQ-5D Index Score

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ABSTRACT

Background: Recently, a vision "bolt-on" EuroQol five-dimensional questionnaire (EQ-5D) was developed and tentative utility values (i.e., a "value set") for this new descriptive system were estimated. **Objectives:** To compare the discriminatory power of this bolt-on and standard utility-based EQ-5D health indices. **Methods:** Cross-sectional data on the (3-level) vision bolt-on EQ-5D were collected through face-to-face interviews with 500 and 336 individuals with and without visual impairment, respectively. To assess the discriminatory power of the vision bolt-on index relative to the standard EQ-5D index developed in the vision bolt-on valuation study, 16 pairs of mutually exclusive subgroups of individuals defined by the individuals' visual acuity and responses to the 14-item visual function questionnaire were compared pairwise. The absolute mean difference in the two index scores and the corresponding F statistic derived from the comparisons were used as measures of discriminatory power. **Results:** The absolute mean difference in the bolt-on index score was larger than that in the standard EQ-5D index score in 14 of the 16 comparisons. The bolt-on index score exhibited a larger F-statistic value than did the standard EQ-5D index score in all known-group comparisons, with the F-statistic ratio ranging from 0.415 to 0.770. **Conclusions:** The vision bolt-on EQ-5D appears to be more discriminative than the standard EQ-5D in measurement of vision problems. Future studies should investigate the extent to which the vision bolt-on item can increase the sensitivity of the EQ-5D to vision change in interventional studies.

Keywords: bolt-on, discriminatory power, EQ-5D, vision problems, visual impairment.

Introduction

Addition of new items, also referred to as "bolt-on" items, has been explored as a means to improving the EuroQol five-dimensional questionnaire (EQ-5D) [1–6]. Bolt-on items usually take the same form as do EQ-5D items but target different health dimensions. The aim of this exercise is to increase the sensitivity of the EQ-5D in therapeutic areas in which the performance of the standard version is suboptimal. For example, if the EQ-5D is not sensitive to the impact of eye diseases, addition of an item assessing vision problems may mitigate the problem.

Research on bolt-on items has focused on their measurement properties and valuation of health states defined by the bolt-on descriptive system. Bolt-on items seem to enhance measurement. For example, studies showed that a cognition bolt-on item captured additional health information when added to the EQ-5D [1,2]. The effect of bolt-on items on valuation of the resultant health states, however, appeared to be complex [3]. Although the utility values of all the possible health states (aka the "value set") were successfully determined for a vision [4] and a psoriasis [5] bolt-on system, a sleep bolt-on item was found to add no value to the EQ-5D [6]. It was because the sleep problems described by the item had little impact on overall health utility compared with health problems captured by the existing EQ-5D items. Therefore, the additional information captured by bolt-on items may not necessarily translate into a more sensitive utility-based health index.

One important question that has not yet been answered for the bolt-on exercise is whether the utility-based index for the bolt-on health states (hereafter referred to as the bolt-on index) is more sensitive than the standard EQ-5D index (hereafter referred to as the "standard" index) in empirical studies. The utility-based health index is a convenient outcome measure for medical decision making and cost-effectiveness analysis of health technologies, and it is the main reason for the popularity of the EQ-5D. Like any new health-status measure, a bolt-on index should be psychometrically validated before formal use. Therefore, the

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purpose of this study was to assess the discriminatory power or sensitivity to difference of a vision bolt-on index [4] in terms of its ability to discriminate between individuals with different levels of vision problems. Through this study, we hope to evaluate the prospect of the bolt-on exercise as an approach to developing new utility-based measures.

Methods

We used data from a burden-of-illness study for visual impairment (VI) in Singapore, a city-state in Southeast Asia. In that study, health and economic burden of individuals with and without VI was assessed in a cross-sectional survey. The study design is briefly described below.

Individuals with VI

Consecutive patients attending specialist outpatient clinics in Singapore National Eye Centre, a tertiary eye center that manages about half of all eye conditions in Singapore, were recruited. The study was approved by the Institutional Research Board. The patients' inclusion criteria were 1) a clinical diagnosis of cataract, glaucoma, diabetic retinopathy, or age-related macular degeneration for at least 3 months; 2) age 40 years or above; 3) Singapore citizen or permanent resident; 4) VI in both eyes; and 5) able to communicate or accompanied by a caregiver who could communicate in English or Chinese. After informed consent was obtained, each patient or his or her caregiver was interviewed face-to-face in the hospital by a bilingual research assistant using a battery of standardized questionnaires including, in the order of administration, the (3-level) vision bolt-on EQ-5D, the 14-item visual function questionnaire (VF-14) [7], and a health services utilization and expenditure questionnaire.

Individuals without VI

Members of the general public who volunteered to be screened for eye diseases on the 2013 National Eye Care Day, which was conducted at the Singapore National Eye Centre, were recruited. Inclusion criteria were 1) clinically confirmed absence of cataract, glaucoma, diabetic retinopathy, and age-related macular degeneration; 2) age 40 years or above; 3) Singapore citizen or permanent resident; 4) absence of VI in both eyes; and 5) able to communicate in English or Chinese. Following informed consent, each subject was visited at home and interviewed face-to-face by a trained interviewer using the same set of questionnaires for individuals with VI.

Definition of VI

In this study, presenting visual acuity was measured by a trained optometrist for each individual as a logarithm of the minimum angle of resolution (logMAR) chart (Lighthouse International, New York, NY) at a distance of 4 m, with the individual wearing his or her habitual optical correction (e.g., spectacles or lenses). If no numbers could be read at 4 m, the individual moved to 3, 2, or 1 m, consecutively. If no number could be read on the chart, visual acuity was treated as counting fingers, hand movement, perception of light, or no perception of light. VI was classified according to the visual acuity in the better-seeing eye as follows: 1) mild VI (logMAR $\geq$0.30–$<$0.48), 2) moderate VI (logMAR $\geq$0.48–$<$1.00), 3) severe VI (logMAR $\geq$1.00–$<$1.30), and 4) blindness (logMAR $\geq$1.30) [8,9].

Instruments

EQ-5D

The vision bolt-on EQ-5D comprises two parts: the 3-level EQ-5D descriptive system and a vision item. The EQ-5D descriptive system consists of five items, each for a different dimension: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Respondents were asked to describe their health status on the day of the survey in those dimensions as "no problems," "some problems," or "extreme problems." The vision item developed by Longworth et al. [4] was used in this study. It consists of the heading "Vision (using glasses or contact lenses if needed)" and the response options "I have no problems seeing," "I have some problems seeing," and "I have extreme problems seeing." The vision item followed the EQ-5D items in the questionnaire and was administered immediately after the EQ-5D items in this study. Both the English and Chinese versions of the EQ-5D were validated in local patients undergoing cataract surgery [10] and those with age-related macular degeneration [11].

In this study, the vision bolt-on and standard EQ-5D value sets developed by Longworth et al. [4] were used to generate the bolt-on score and the standard index score, respectively. The two value sets were simultaneously developed using identical sampling, valuation, and data modeling procedures to study the impact of adding the vision dimension on the valuation of EQ-5D health states [4]. Both value sets were estimated using time trade-off utility values of 20 health states directly measured from a general population sample drawn from Yorkshire, England ($n = 155$ for standard and 157 for bolt-on). The standard index score values range from –0.072 for the worst health state to 1.018 for the best health state. In this study, the only greater than one value for the best health state was truncated to 1.000 to achieve comparability with bolt-on score values, which range from –0.015 to 1.000.

VF-14

The VF-14 assesses the level of difficulty in performing activities of daily living due to vision problems. Each of the 14 items in this questionnaire measures a different vision problem using a five-point Likert response scale ranging from 0 (no difficulty) to 4 (unable to perform activity). The instrument has been validated in the Singaporean population previously [12].

Statistical Analysis

The discriminatory power of the bolt-on index score was assessed by comparing the ability of bolt-on and standard index scores to discriminate between paired groups of individuals known to differ in VI severity or vision problems. For this purpose, four pairs of known groups were defined according to VI severity: no VI versus mild VI, mild VI versus moderate VI, moderate VI versus severe VI, and severe VI versus blindness; 12 pairs of known groups were defined using self-reported vision problems with VF-14, each pair for a different vision problem. These vision problems included reading small print, reading newspapers, reading large print, recognizing people, seeing steps, reading traffic signs, doing handwork, filling forms, playing games, taking part in sports, cooking, and watching TV. Difficulty in car driving was assessed in VF-14 but was excluded from this analysis because very few participants drove or had driven a car. For each vision problem, the two known groups consisted of a group with problems (defined as reporting "a little," "some," or "a great deal" of difficulty or "unable" to perform the related activity) and a group without problems (defined as reporting "no" difficulty in performing the related activity).

Discriminatory power was first assessed using the absolute mean difference in the index scores between the known groups defined by participants' VI severity and VF-14. A larger difference means greater utility gains and therefore a higher chance of drawing the conclusion of cost-effectiveness when the index is used in a cost-utility analysis, thus indicating higher discriminatory power. Discriminatory power was also assessed in terms of the squared t statistic derived from the two-sample t test of index scores between the known groups. The squared t statistic (equivalent to the F statistic from the analysis of variance test in value) is widely used to assess the relative efficiency of patient-reported outcome measures [13–15]. A higher F-statistic value means a higher likelihood for the measure to show statistical significance when used to compare groups. Hence, higher F-statistic values indicate higher discriminatory power. In this study, the F-statistic ratio of the two index scores was calculated for each pair of the known groups in such a way that a ratio of less than 1 would mean that the bolt-on index score is more discriminative. The ratio can be interpreted in terms of the relative sample size needed to achieve statistical significance [16]. For example, a ratio of 0.5 means that the bolt-on index can achieve the same statistical power as the standard index with only half of the sample size for the latter when they are used to compare the two groups.

The differences in index scores between the known groups and their corresponding F statistics were also estimated using multiple linear regression models in which the effect of age and sex was adjusted. The adjusted difference and the F statistic are better indicators than the unadjusted estimates of the sensitivity to change (or responsiveness) of index scores in longitudinal studies. All analyses were conducted using SAS for Windows (version 9.2, SAS Institute, Inc., Cary, NC) at the significance level of 0.05.

Results

Sample Characteristics

A total of 500 individuals with VI were recruited. Their mean age was 71.6 ± 9.8 years, and 47.6% were men. Most of the individuals were Chinese (88.0%), with primary or no formal education (64.2%), not working (80.2%), and married (86.2%). The mean ± SD for the bolt-on and standard index scores was 0.90 ± 0.15 and 0.91 ± 0.15, respectively. The full sociodemographic and health characteristics of individuals with VI are presented in Table 1.

A total of 336 individuals without VI participated in the study. Their mean age was 63.1 ± 7.4 years, and 36.3% were men. Most of them were Chinese (95.8%), with secondary education (68.2%), not working (58.3%), and married (77.4%). The mean ± SD for the bolt-on and standard index scores was 0.97 ± 0.05 and 0.96 ± 0.06, respectively. Compared with individuals with VI, those without VI were significantly younger, better educated, more likely to work, and healthier according to the EQ-5D (Table 1).

Absolute Mean Differences between Known Groups

The bolt-on and standard index scores both decreased monotonically with increasing VI severity (Table 2). The mean absolute difference in the bolt-on and standard index scores was 0.055 and 0.036, respectively, between individuals without VI and with mild VI, 0.015 and 0.017, respectively, between individuals with mild VI and moderate VI, and 0.042 and 0.031, respectively, between individuals with moderate and severe VI; the difference in both index scores was 0.032 between individuals with severe VI and blind individuals. For each of the 12 vision problems assessed by VF-14, both index scores were higher in individuals without a problem than in those with the problem. The absolute mean differences between the known groups ranged from 0.074 to 0.155 and 0.061 to 0.135 for the bolt-on and standard index scores, respectively, with the difference in the bolt-on index score being larger than the corresponding difference in the standard index score for all the 12 vision problems (Table 3).

After adjusting for the effect of age and sex, the absolute mean differences between the known groups were attenuated for both bolt-on and standard index scores. As can be seen in Tables 2 and 3, the bolt-on index score still exhibited a larger mean absolute difference than did the standard index score in all but two known-group comparisons. The absolute mean difference in bolt-on and standard index scores was 0.012 and 0.014 between individuals with mild and moderate VI and 0.049 and 0.051 between individuals with severe VI and blind individuals, respectively.

F-Statistic Ratios for Known Groups

The F-statistic ratio of the standard index score versus the bolt-on index score derived from the comparisons of the groups known to differ in VI severity ranged from 0.415 to 0.667, with the mean being 0.525 ± 0.110 (Table 2). Similarly, the F-statistic ratios derived from the comparisons of individuals with and without a vision problem were less than 1 for all 12 vision problems, with the range being 0.571 to 0.770 and the mean being 0.678 ± 0.057 (Table 3). The F-statistic ratios became smaller in all but one known-group comparisons after adjusting for the effect of age and sex (Tables 2 and 3); in the comparison of individuals with severe VI and those who were blind, the adjusted F-statistic ratio was 0.668, higher than the unadjusted value of 0.550.

Discussion

In this study, we found that the vision bolt-on EQ-5D index score was more discriminative than the standard EQ-5D index score to different levels of visual problems. To our knowledge, this is the first empirical study showing that a bolt-on EQ-5D index score had higher discriminatory power than did the standard EQ-5D index score. A previous study found that a cognition bolt-on item might increase the sensitivity of the EQ-5D to change (or responsiveness) in the elderly population [2]. The preference-based EQ-5D index score, however, was not assessed in that study. Hence, our study provided the first evidence for the value of the bolt-on exercise in developing utility-based measures with better measurement properties.

The vision bolt-on EQ-5D exhibited a larger difference than did the standard EQ-5D in 14 of 16 comparisons of groups known to differ in vision status, suggesting that it would demonstrate greater gains than the latter for interventions that can improve vision acuity or function. Although the advantage in utility gains as indicated by adjusted mean absolute differences of the two index scores was only between 0.01 and 0.03, it may still increase the chance of showing positive results in economic evaluation studies. For example, if a new intervention can improve mildly impaired vision to normal vision and maintain it for 10 years, the incremental gains in quality-adjusted life-years (QALYs) for an individual treated by the intervention as compared with the usual care that can only maintain the current vision would be 0.48 and 0.30 based on the bolt-on and standard EQ-5D, respectively, according to our study. Assuming that the incremental costs for the intervention as compared with usual care are $15,000, the point estimate of the incremental cost-effectiveness ratio based on the bolt-on and standard EQ-5D would be $31,250/QALY and $50,000/QALY, respectively. If the decision maker's willingness-to-pay threshold is $40,000/QALY, the use of the two index scores would lead to completely different conclusions. Therefore, the seemingly small advantage of the vision bolt-on EQ-5D over the standard EQ-5D in economic evaluations should not be underestimated.

Table 1 – Characteristics of participants with and without VI.

Characteristic	All (N = 836)	Individuals with VI (n = 500)	Individuals without VI (n = 336)
Age (y), mean ± SD	68.2 ± 9.9	71.6 ± 9.8	63.1 ± 7.4
Sex			
Male	43.1 (360)	47.6 (238)	36.3 (122)
Ethnicity			
Chinese	91.2 (91.2)	88.0 (440)	95.8 (322)
Indian	3.8 (32)	5.4 (27)	1.5 (5)
Malay	4.3 (36)	5.4 (27)	2.7 (9)
Others	0.7 (6)	1.2 (6)	0.0 (0)
Education			
No formal education	25.6 (214)	34.6 (173)	12.2 (41)
Primary education	25.6 (214)	29.6 (148)	19.6 (66)
Secondary education	48.8 (408)	35.8 (179)	68.2 (229)
Employment status			
Working	28.6 (239)	19.8 (99)	41.7 (140)
Not working	71.4 (597)	80.2 (401)	58.3 (196)
Marital status			
Single	8.3 (69)	6.6 (33)	10.7 (36)
Married	82.7 (691)	86.2 (431)	77.4 (260)
Separated/divorced	1.8 (15)	1.4 (7)	2.4 (8)
Widow	7.3 (61)	5.8 (29)	9.5 (32)
Interview language			
English	40.7 (340)	36.0 (180)	47.6 (160)
Chinese	59.3 (496)	64.0 (320)	52.4 (176)
EQ-5D index score, mean ± SD			
Bolt-on	0.93 ± 0.12	0.90 ± 0.15	0.97 ± 0.05
Standard	0.93 ± 0.12	0.91 ± 0.15	0.96 ± 0.06
Mobility			
No problems	77.9 (651)	68.0 (340)	92.6 (311)
Some problems	20.7 (173)	29.6 (148)	7.4 (25)
Extreme problems	1.4 (12)	2.4 (12)	0.0 (0)
Self-care			
No problems	92.6 (774)	87.8 (439)	99.7 (335)
Some problems	5.5 (46)	9.0 (45)	0.3 (1)
Extreme problems	1.9 (16)	3.2 (16)	0.0 (0)
Usual activities			
No problems	86.0 (719)	78.2 (391)	97.6 (328)
Some problems	10.8 (90)	16.4 (82)	2.4 (8)
Extreme problems	3.2 (27)	5.4 (27)	0.0 (0)
Pain/discomfort			
No problems	61.7 (516)	60.2 (301)	64.0 (215)
Some problems	35.9 (300)	36.4 (182)	35.1 (118)
Extreme problems	2.4 (20)	3.4 (17)	0.9 (3)
Anxiety/depression			
No problems	80.9 (676)	78.4 (392)	84.5 (284)
Some problems	18.3 (153)	20.2 (101)	15.5 (52)
Extreme problems	0.8 (7)	1.4 (7)	0.0 (0)
Vision			
No problems	51.8 (433)	26.6 (133)	89.3 (300)
Some problems	41.0 (343)	61.6 (308)	10.4 (35)
Extreme problems	7.2 (60)	11.8 (59)	0.3 (1)

Note. The number inside the parentheses is the number of participants, and the number outside them is the proportion, unless otherwise specified.
VI, visual impairment.

It should be noted that the bolt-on index score may not always be advantageous to the standard EQ-5D index score in economic evaluations. In two comparisons of individuals with different levels of VI, the absolute difference quantified by the two index scores differed by only 0.002, with the standard EQ-5D being the more discriminative one. Although the difference is too small to affect the outcomes of economic evaluations, this result suggests that the vision bolt-on item may not always increase the discriminatory power of the index score, especially when the difference between the groups and the sample size of the groups are both small. Despite this result, the bolt-on EQ-5D should potentially be considered as the first choice for use in economic evaluations in patients with vision-related problems because it performed as well as or better than the standard EQ-5D in all conditions studied.

Table 2 – EQ-5D index scores for different VI groups, mean differences between groups, and corresponding F-statistic ratios.

VI severity	n	Mean ± SD		Unadjusted mean difference*		Unadjusted F-statistic ratio	Adjusted mean difference*		Adjusted F-statistic ratio
		Bolt-on	Standard	Bolt-on	Standard		Bolt-on	Standard	
No VI	336	0.970 ± 0.048	0.960 ± 0.058	0.055	0.036	0.415	0.048	0.030	0.370
Mild VI	305	0.916 ± 0.114	0.924 ± 0.113	0.015	0.017	0.667	0.012	0.014	0.578
Moderate VI	78	0.902 ± 0.119	0.907 ± 0.131	0.042	0.031	0.468	0.040	0.028	0.435
Severe VI	39	0.860 ± 0.201	0.876 ± 0.209	0.032	0.032	0.550	0.049	0.051	0.668
Blindness	78	0.828 ± 0.218	0.844 ± 0.218						

EQ-5D, EuroQol five-dimensional questionnaire; VI, visual impairment.
* Difference between a group and its immediate next group.

Table 3 – EQ-5D index scores for different visual function groups, mean differences between groups, and corresponding F-statistic ratios.

Vision-related activity	Mean ± SD: Without problems	Mean ± SD: With problems	Unadjusted difference	Unadjusted F-statistic ratio	Adjusted difference	Adjusted F-statistic ratio
Reading small print	n = 337	n = 449				
Bolt-on	0.970 ± 0.090	0.896 ± 0.133	0.074	0.666	0.064	0.654
EQ-5D	0.964 ± 0.091	0.903 ± 0.135	0.061		0.052	
Reading newspaper	n = 442	n = 391				
Bolt-on	0.964 ± 0.089	0.882 ± 0.141	0.082	0.618	0.071	0.596
EQ-5D	0.958 ± 0.090	0.893 ± 0.145	0.066		0.056	
Reading large print	n = 674	n = 162				
Bolt-on	0.952 ± 0.085	0.815 ± 0.183	0.137	0.672	0.128	0.666
EQ-5D	0.950 ± 0.088	0.834 ± 0.188	0.116		0.108	
Recognizing people	n = 696	n = 140				
Bolt-on	0.949 ± 0.09	0.811 ± 0.186	0.138	0.638	0.131	0.629
EQ-5D	0.946 ± 0.094	0.833 ± 0.191	0.114		0.108	
Seeing steps	n = 671	n = 165				
Bolt-on	0.953 ± 0.086	0.815 ± 0.178	0.138	0.705	0.129	0.701
EQ-5D	0.951 ± 0.089	0.831 ± 0.183	0.120		0.112	
Reading traffic signs	n = 668	n = 168				
Bolt-on	0.951 ± 0.089	0.823 ± 0.177	0.129	0.625	0.119	0.612
EQ-5D	0.949 ± 0.092	0.843 ± 0.182	0.105		0.097	
Doing handwork	n = 509	n = 275				
Bolt-on	0.959 ± 0.078	0.854 ± 0.165	0.105	0.770	0.097	0.755
EQ-5D	0.958 ± 0.079	0.864 ± 0.168	0.094		0.087	
Filling forms	n = 556	n = 272				
Bolt-on	0.958 ± 0.083	0.859 ± 0.161	0.098	0.705	0.088	0.697
EQ-5D	0.955 ± 0.083	0.871 ± 0.167	0.084		0.075	
Playing games	n = 547	n = 168				
Bolt-on	0.946 ± 0.095	0.829 ± 0.179	0.117	0.722	0.109	0.715
EQ-5D	0.946 ± 0.096	0.844 ± 0.186	0.102		0.095	
Taking part in sports	n = 535	n = 166				
Bolt-on	0.943 ± 0.098	0.831 ± 0.177	0.113	0.730	0.106	0.719
EQ-5D	0.944 ± 0.098	0.846 ± 0.184	0.098		0.093	
Cooking	n = 672	n = 126				
Bolt-on	0.947 ± 0.092	0.792 ± 0.183	0.155	0.711	0.146	0.708
EQ-5D	0.946 ± 0.095	0.811 ± 0.191	0.135		0.128	
Watching TV	n = 629	n = 207				
Bolt-on	0.954 ± 0.084	0.838 ± 0.172	0.116	0.571	0.108	0.560
EQ-5D	0.950 ± 0.088	0.859 ± 0.178	0.091		0.084	

EQ-5D, EuroQol five-dimensional questionnaire.

Our study suggests that the bolt-on index score would be more discriminative than the standard EQ-5D index score when they are used in studies aiming to detect statistically significant difference. Based on the F-statistic ratios, the bolt-on index score is more likely than the standard EQ-5D index score to show statistically significant results, which means that a smaller sample size is needed when the bolt-on index substitutes the standard EQ-5D index as the primary outcome measure in a clinical trial. This advantage of the bolt-on index score was present in all the known-group comparisons, including the two comparisons in which the standard EQ-5D index score demonstrated a larger absolute mean difference. This is not surprising because the F statistic is a function of both the mean difference between groups and the SD of the index scores [13]. When the mean difference is relatively small, a relatively higher F-statistic value is still possible if the corresponding SD is small. The SD of the bolt-on index score was smaller than that for the standard EQ-5D index score for almost all the comparison groups in this study. Because the two indices use the common scale anchored by 0 (dead) and 1 (full health), this result means that the bolt-on index score could provide measurements with less error or higher reliability for the comparison groups. The higher F-statistic values suggest that the vision bolt-on item not only captured a unique difference between known groups but also meaningfully affected the index score. The F-statistic ratios also suggest that the advantage of the bolt-on index score to the standard EQ-5D index score is greater in discriminating different levels of VI than in discriminating vision problems. This could be because certain standard EQ-5D items such as the usual activities and the VF-14 captured some common information. As a result, the added value of the vision item to the EQ-5D is less when the target of measurement is defined by the VF-14. Taken together, our study suggested that it would be more advantageous to use the vision bolt-on EQ-5D than the standard EQ-5D in hypothesis-testing studies. This is good news because the performance of the standard EQ-5D in visual disorder was found to be mixed [17].

The main limitation of this study is the use of experimental value sets estimated using a relatively small general population sample. There is currently no official bolt-on value set. Therefore, what we showed in the study is just the potential of the vision bolt-on item in empirical studies, and the utility values reported in this article should not be used in any formal economic evaluation. Also, it should be noted that discriminatory power is sensitivity to difference but not sensitivity to change or responsiveness, although a higher discriminatory power may be a sign of better responsiveness. Hence, future studies are needed to assess the relative sensitivity of the bolt-on and standard EQ-5D in interventional studies. Last, this study was based on observation of a vision bolt-on item in Asians with and without vision problems. Hence, the study findings might not be generalizable to other populations or bolt-on items. Nevertheless, this study is well powered by a large sample of individuals and it has provided the first information about the potential of the bolt-on exercise in the real world.

In conclusion, the vision bolt-on EQ-5D appears to be more discriminative than the standard EQ-5D in measurement of vision problems. Future studies should investigate the extent to which the vision bolt-on item can increase the sensitivity of the EQ-5D to vision change in interventional studies.

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